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BELLCOMM, INC.

955 L'ENFANT PLAZA NORTH, S.W.

WASHINGTON, D. C. 20024

B70 07040

SUBJECT: Potential Application of MSC On-Board
Checkout System for Performance of
Other Data Management Functions on
Manned and Unmanned Spacecraft -
Case 105-4

DATE: July 14, 1970

FROM: A. L. Schreiber
M. H. Skeer

ABSTRACT

MSC, under a contract to Martin Marietta Corp., has developed an on-board checkout system (OCS) for potential operation in association with a space station or space base. The label "OCS" is somewhat misleading in that it obscures the potential capabilities of the system for performance of other data management functions. This memorandum reviews the current status of the OCS and considers the implications of extended capabilities for design of data management systems for manned and unmanned spacecraft.

In the process of developing a capability to perform on-board checkout operations many of the hardware elements required for other data management operations have also been developed. These include 1) a network by which access to varied subsystem components can be acquired, 2) a compact, low weight computer capable of performing general purpose data management functions, 3) an associated data interchange and control unit which provides the interface with the external environment, and 4) a control and display unit to provide convenient implementation of input/output instructions. These functions can make the OCS suitable for application in both manned and unmanned spacecraft.

For manned space stations, integrated data management systems have been proposed which encompass all functions heretofore performed by separate data management systems. An integrated data management system can also be envisioned for unmanned satellites. Advanced satellites capable of supporting multidisciplinary sensors and experiments could be a desirable means of concentrating unmanned payloads in only a few orbits to be visited by the space shuttle. Such a satellite would be, in effect, an unmanned space station capable of long term operation. As suggested by the OCS program, data management system technology appears to be approaching the state-of-the-art essential for implementation

(NASA-CR-113111) POTENTIAL APPLICATION OF
MSC CN-BOARD CHECKOUT SYSTEM FOR PERFORMANCE
OF OTHER DATA MANAGEMENT FUNCTIONS ON MANNED
AND UNMANNED SPACECRAFT (Bellcomm, Inc.)

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MEMORANDUM FOR FILE

INTRODUCTION

MSC, under a contract to Martin Marietta Corp., has developed an on-board checkout system (OCS) for potential operation in association with a space station or space base. This memorandum reviews the current status of the OCS and considers the implications of these extended capabilities for design of data management systems for manned and unmanned spacecraft. A trip to MSC by the authors was undertaken on May 26, 1970 for discussions with principal NASA and Martin personnel engaged in development of the OCS. These included T. V. Chambers and J. F. Hughes of NASA's Information Systems Division, and W. Wise of the Martin Co. The contract cost for this program was \$1.3 million.

Details of the OCS have been briefly described in a previous Bellcomm Memorandum for File (Reference 1). The label "OCS" is somewhat misleading in that it obscures the potential capabilities of the system for performance of other data management functions. In addition to the monitoring and diagnostic capability inherent in OCS operation, reasonable extension of the design permits incorporation of process control and data processing functions.

POTENTIAL DATA MANAGEMENT SYSTEM FUNCTIONS

Integrated data management systems for manned space stations have been proposed which encompass all functions heretofore performed by separate data management systems tailored to peculiar requirements of individual subsystems or operations. Among the functions that could be included (noted in Reference 2) are:

- * Operations and Status Information - functions performed to minimize personnel requirements and maximize crew safety.

- Base Log Information - maintenance of historical records of operational events and conditions for use by flight and ground personnel (for example; results of preventive maintenance performed).
- Logistic Information - status monitoring of requirements for consumables resupply and refurbishment of limited life components including spares inventory.
- Process Control Information - real time control of basic operations of processes or systems, limiting the personnel interface principally to selection of the operational mode and data output.
- Ground Information - transmission and reception of selected status information and data from the ground.
- Scientific Information - processing and storing of scientific data from operation of onboard and free flying experiments.
- Maintenance Information - various levels of subsystems tests for detection and isolation of faults and evaluation of repairs.
- Biomedical Information - analysis and monitoring of data generated from personnel.

OCS DESCRIPTION

Elements of the OCS necessary to perform basic on-board checkout functions (Reference 3) have the inherent capability to perform process control, command and control (beyond checkout) and various other data-processing functions aboard the spacecraft. These elements are the

- Airborne digital computer (ADC),
- Stimulus Bus (SB),

- Measurement bus (MB),
- Control and display unit (CADU), and the
- Data interchange and control unit (DIACU).

A description of the OCS (Figure 1) is provided to lend insight into the character of the OCS and how the aforementioned functions could be implemented.

The ADC is currently an IBM 4 PI/EP general purpose digital computer with a 24 K memory of 32-bit words and a 2.5 μ sec cycle time. (The 4 PI/EP instruction set is compatible with the IBM 360 instruction set, permitting external compilation and some program screening.) The ADC weighs 62 lbs, occupies 0.9 cu ft and uses 303 watts. (By way of a gross comparison with the Bellcomm UNIVAC 1108 installation, six of the ADC's would have roughly the same main-frame computing power and nine ADC's would have slightly more main memory.) The ADC is capable of reading from and writing on external mass storage (drums, tapes, non-mechanical auxiliary memory) but this function is not contemplated for the OCS.

The SB is composed of a signal generating unit (SGU), a signal switching unit (SSU) and wired connections to all points where a signal may be desired. The SGU can generate signals from DC to 100 khz AC with a range of 7.5 mv to 40 v (not all combinations). The SSU determines which point receives the stimulus. Both the SGU and the SSU are under the control of the ADC.

The MB is comprised of a measurement unit (MU), a measurement switching unit (MSU), and a wired connection to all points from which measurements may be desired. The MU can measure signals from DC to 100 khz AC within a 10 mv to 40 v range (not all combinations), and the MSU determines which point receives the stimulus. The MU and the MSU are also under the control of the ADC.

The CADU is the interface between the astronaut and the OCS. As such it has four elements:

- A typewriter-like keyboard with alphanumerics, special symbols and functions,
- A plasma display --- a rectangular array of points, any combination of which can be turned on or off by the ADC,

- A microfilm display screen,
- Small removable microfilm cassettes with 6000-frame capacity.

The keyboard is used by the astronaut to control the OCS and to give informations to the ADC. He receives prerecorded information from the microfilm display with the appropriate cassette installed. The plasma display is only used to display alphanumeric and special symbols on 7 point by 5 point grids.

The DIACU is an interface between the ADC and its external environment. It formats, routes, and converts digital data and supplies timing information to the ADC as required.

Two pieces of software operate in the ADC --- the Spaceborne Executive Control System (SEC), and the Test Oriented Onboard Language (TOOL). SEC is a standard executive system which could support any number of application programs, and TOOL is the application package used. SEC handles interrupts, input/output, and general scheduling and supervision for the ADC.

TOOL is the operating program for the entire OCS system and is under the direction of the astronaut through the CADU (Figure 1). TOOL tests spacecraft subsystems using the SB and MB and outputs such information as is required to the CADU. It can operate in an automatic checkout mode on a predetermined set of tests and reports, or it can respond in a demand mode to astronaut or ground test programming within a great range of generality.

Demand programming of the OCS is done in an interpretive mode. That is, there is no modification to the TOOL program, but rather the test steps specified through the CADU become input data for TOOL. These input data then drive the OCS through the specified tests and reports.

UTILIZATION OF OCS FOR SKYLAB II AND MANNED SPACE STATIONS

The OCS has been proposed for Skylab I for inclusion as an experiment, however, scheduling problems preclude incorporation in that mission. The OCS is now being proposed for Skylab II, this time as an integral part of the mission.

The collection of elements comprising the OCS, as noted, has capabilities transcending the checkout of subsystems. In advanced space stations, a modified OCS/Data Management System would perform monitoring, process-control, command and control, and data management functions (Reference 2). In the present configuration, no significant functions beyond onboard checkout could be performed without increased computer memory in which to store the additional applications programs.

Proposals for autonomous data management systems for Space Stations of the late 70's suggest that it is desirable to understand the degree to which automated data management functions should be incorporated. It might therefore be worthwhile to explore such capabilities in the Skylab II experiment program if scheduling and funding permit.

POTENTIAL APPLICATION OF THE OCS TO UNMANNED SYSTEMS

The marked advance in data management systems suggest applications for unmanned satellites as well as for manned space stations. The potential impact of advance data management systems must be viewed in the context of the transportation systems envisioned in the late 70's and 80's time period and the impact of these transportation systems on unmanned satellites. The space transportation system comprised of the Earth to Orbit Shuttle and Orbit to Orbit Tug, is envisioned to provide the capability to launch, visit, or return satellites at greatly reduced transportation costs. Visit of satellites for servicing could greatly enhance satellite performance and operations by implementing such functions as repair, updating, resupply, refurbishment, and salvage. To capitalize on shuttle utilization, it will be desirable to cluster payloads for ease and economy of revisit. Standardized servicing interfaces will likely be incorporated in the satellite and standardization and accessibility of components for simplification of servicing tasks would likely be required. These factors suggest new satellite design concepts will evolve to exploit space shuttle capabilities. Such a satellite would be a maintainable, long term subsystems platform that provides subsystem support for multidisciplinary sensor packages which could be changed throughout the satellite lifetime. This requires a flexibility to accommodate variable sensor requirements and necessitate acceptance of design constraints for both subsystem and sensors. The nature of these constraints could possibly include:

- controlled interface and tolerance levels,
- modular design of components, and
- variable subsystem performance levels, i.e.
 - power
 - data rate
 - status monitoring
 - stability and pointing control, and
 - thermal control.

Clearly, for satellites of this nature, the data management system must assume an expanded role. In addition to processing and storing of scientific data and status information, maintenance information and process control functions must be incorporated. Maintenance data would permit efficient servicing operations to be performed and process control would be necessary for accommodation of various interface requirements. For example, the subsystems might be designed to provide several discrete levels of power or data input/output. A sensor to be incorporated in the satellite on orbit would be designed to selected interface levels. Interfaces such as thermal output, c.g. control, etc., would be accommodated by the satellite by louvre adjustment, ballast control, etc. In this instance, the data management system could ensure specified performance by control of the power distribution, data transmission, thermal control, and c.g. control systems. These functions are similar to requirements placed on an OCS for manned space station operation.

SUMMARY

In the process of developing a capability to perform onboard checkout operations many of the hardware and software elements required for other data management operations have been developed. These include

- a network (comprised of the stimulus bus and measurement bus) by which access to varied subsystem components can be acquired;

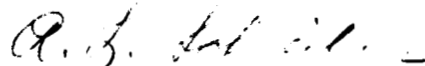
- a compact, low weight computer capable of performing general purpose data management functions;
- a real time executive control system for the computer;
- an associated data interchange and control unit which provides the interface with the external environment; and
- a control and display unit to provide convenient implementation for input/output instructions.

As such, the OCS has demonstrated an approach by which a general purpose data management system capability can be achieved. Such a system could have application both for manned and unmanned spacecraft.

For manned space stations, integrated data management systems have been proposed which encompass all functions heretofore performed by separate data management systems. Similar systems can also be envisioned for unmanned satellites. Advanced satellites capable of supporting multidisciplinary sensors and experiments could be a desirable means of concentrating unmanned payloads in only a few orbits visited by the space shuttle. Such a satellite would be, in effect, an unmanned space station capable of long term operation. As suggested by the OCS, data management system technology appears to be approaching the state-of-the-art which would be essential for implementation of such a concept.

ACKNOWLEDGEMENT

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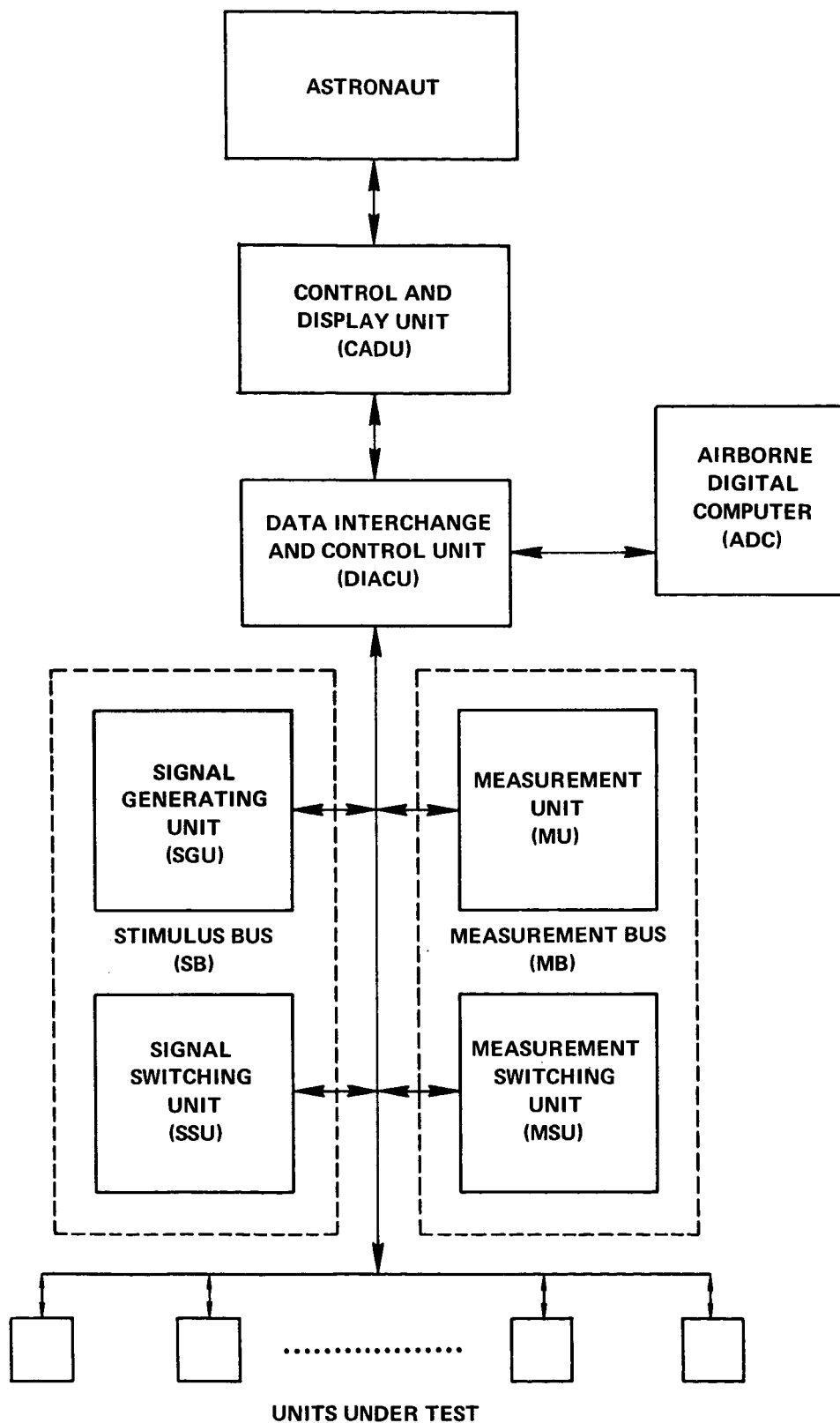


FIGURE 1 - SCHEMATIC OF ONBOARD CHECKOUT SYSTEM (OCS)